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2014-2016 Avian Point Count and Migration Surveys at Site 300 for the Lawrence Livermore National Laboratory

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Milestone 5
Final Report

2014-2016
Avian Point Count and Migration Surveys at Site 300
for the
Lawrence Livermore National Laboratory

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Background

Garcia and Associates (GANDA) was contracted by the Lawrence Livermore National Laboratory (LLNL) to conduct avian point counts and raptor migration surveys within Site 300. This report summarizes the methods and results of these surveys and provides a discussion of the significance of the results.

Study Area

Survey locations were predetermined by LLNL. The study area included four main locations within Site 300 for large bird point counts and migration surveys: West Observation Point (WOP), East OP (EOP), Linac Road (LRD), and Building 849 (849). For the small bird point counts eight additional locations were also surveyed within the vicinity of the original four points: WOPa, WOPb, EOPa, EOPb, LRDa, LRDb, 849a, and 849b.

Methods

The primary goals of the surveys were to: 1) collect minutes of bird activity within Site 300, 2) consider relative abundance of the different bird species occurring within the Site, 3) collect behavioral information, and 4) provide compelling evidence to determine the status of the Site as a migration corridor or migration stopover site. To this end, two survey types were conducted: avian point counts were conducted on a monthly basis from February 2014 through January 2016 and migration surveys were conducted over two three-month periods from September 2014 through November 2014, and September 2015 through November 2015. These two survey types provided the opportunity to observe avian species in a variety of conditions across a two year period. Whenever possible or relevant, the observations of either survey were used to inform and complement the observations of the other survey in pursuit of the above goals. Both survey types are described below.

Avian Point Counts

GANDA biologists Eric Jepsen, Brittney Wendell, and Graham Lewis conducted point count surveys one day per month during February 2014 through January 2016. Two types of point count surveys were performed: 800 m radius for birds larger than crow-sized and 100 m radius for birds smaller than crow-sized. The large bird surveys extended 800 m horizontally from the observer and 200 m vertically for 90 minutes at each of four observation points. The small bird surveys included the area extending 100 m horizontally from the observer and 100 m vertically for 30 minutes at each of eight locations.

For all point count surveys, the GANDA biologists followed the raptor flight observation protocol presented by Smallwood and Thelander (2004), as described in Smallwood and Neher (2008). This survey protocol is designed to quantify the number of minutes that a given individual or flock spends within the survey area, and the behaviors that may be observed during each minute of observation. Observations of individuals or flocks were recorded at the end of

each minute that they were observed during the survey. To maximize observer efficiency, all information was recorded with a digital voice recorder, for transcription following the survey.

All data were transcribed into an Excel spreadsheet within 48 hours of the conclusion of the avian point count survey to minimize errors. During the data entry portion of the protocol, each bird or group of birds that appeared within the survey area was assigned a letter according to its sequence entering the survey area. A number was then assigned to each bird to represent the minute during the survey period when the observation was made. The observation of the first bird entering the survey area after the first minute of the session was reported as A1, and the observation of a second bird entering the survey area after the first minute was reported as B1. The next observations of these two birds at the end of the next minute were reported as A2 and B2. A bird that left the survey area but remained within sight of the observer retained its original identification letter. Birds that disappeared from sight for >30 seconds were considered different individuals and assigned the next available letter designation if, and when, the bird reappeared. While this likely led to double counting individual birds in some instances, it prevented misclassifying two individual birds entering the plot at different times as one bird.

Each observation was also given a unique identifying code based on the location, date, and its individual observation code. For example, if birds A and B from the above example were observed during a WOP survey on 28 March, the unique ID for each observation became WOP_Mar28_A1, WOP_Mar28_A2, WOP_Mar28_B1, and WOP_Mar21_B8.

Both survey types followed the same general protocol. Upon arrival to the observation point, the surveyor performed a 360-degree visual scan for birds within the survey area, using binoculars and a spotting scope. Any birds heard or seen within the survey area were noted by speaking into a digital audio recorder. For each observation the following information was recorded:

- Location/Date
- Session start time
- Species and number of individuals of each species
- Age Class (if possible)
- Sex (if possible)
- Flight Behavior (Appendix A)
- Direction from Observer (N, NE, E, SE, S, SW, W, NW)
- Direction of Flight (N, NE, E, SE, S, SW, W, NW)
- Perch Structure (Appendix B)
- Distance from observer
- Height above ground
- Interactions with other birds
- Session end time

Once a bird or flock was being visually tracked, the observer focused on that individual as long as it remained within the survey area, unless a higher priority bird entered the survey area. For the large bird counts, survey priority was pre-established by LLNL as follows from highest to lowest priority:

1. Golden eagle
2. Red-tailed hawk,
3. Other hawks in the genus *Buteo*,
4. Prairie falcon or peregrine falcon,
5. White-tailed kite,
6. American kestrel,
7. Owls,
8. Other native birds.

Whenever possible, multiple individuals and flocks were tracked and recorded simultaneously.

Territoriality was also recorded during the large bird point counts. Resident pairs were identified by territorial displays, pairs perched together, and the presence of adult and/or juvenile birds at a nest location. These observations were recorded within the context of the survey; however, we also observed territorial activities while in transit between survey points. Observations made between surveys were useful in making informed calls of territorial behavior that was based on the familiarity that comes with multiple visits to each survey area. It should be noted that GANDA was contracted to conduct golden eagle surveys within Site 300 in addition to the avian point counts and migration surveys described below. The information recorded during these surveys, as well as observations of other raptor activity within Site 300 while en route to the golden eagle survey locations was also useful in identifying resident pairs and territorial activity during the avian point count surveys.

No species prioritization was set for the small bird surveys.

Migration Surveys

GANDA biologists Eric Jepsen and Brittney Wendell conducted migration surveys on multiple dates in September, October, and November 2014 and September, October, and November 2015. The migration surveys were designed to detect and describe migratory movements and patterns along predictable flight lines, should such flight lines exist within Site 300. Unlike the avian point counts, in which the number of minutes of bird activity was the primary metric, the focus of the migration surveys was to count the number of individuals of each large bird species moving through the study area, and to assess the migratory status of those birds.

The migration surveys were initially scheduled as once-per-month, 3-hour surveys performed at the four predetermined locations at Site 300 (WOP, EOP, 849, and LRD). Our first implementation of this protocol on September 9, 2014 revealed high potential for duplicate

observations during concurrent surveys (e.g. 16 pelicans observed by both observers) as well as inadequate temporal sampling across the migration season. All subsequent surveys were conducted individually by Mr. Jepsen from WOP or 849 only. These locations were chosen due to their central location and unobstructed view of a wide area across Site 300. Under this modified protocol, we performed approximately three 4-hour surveys per month in each year. During the survey period, all birds crow-sized or larger (except ravens) were visually tracked. In order to focus on migrants, the locally ubiquitous common raven was not counted. The survey area had an unlimited radius with all observations included to the maximum distance possible. During the migration survey, we only recorded one observation per bird or flock, regardless of the duration of their presence within the study area. For each observation, the following information was recorded:

- Location/Date
- Time and date
- Species
- Age and sex class (if possible)
- Estimated distance from observer and height above ground in meters
- Direction from the observation point (N, NE, E, SE, S, SW, W, NW)
- Direction of travel (N, NE, E, SE, S, SW, W, NW)
- Number of individuals
- Behavior

All observations were recorded with pen onto a paper data form, and transcribed into an Excel spreadsheet immediately following the survey. Within Excel, each observation was assigned an individual identifying code. Perched birds were not assigned a flight direction. Each observation was also assigned a migrant status assessment code of one of the following: Migrant (species/population known for typical, north-south migration, and confirmed by behavior and flight line), Resident (identifiable by territorial display and pair perching together), Dispersing/Unknown (species/population known for directionally non-specific seasonal movements, breeds locally, and behavior and/or flight line does not indicate north-south migration), and Wintering (species/population typically breeds north of California and overwinters in the central California/Central Valley/Diablo Range). This assessment was based on species natural histories and behaviors. Though this migration status assessment was subjective in nature, it allowed the surveyor to differentiate between observations.

Analysis

Following data collection, data entry, and proofing, we summarized the avian point count and

migration data sets and analyzed them for rates of species incidence and trends. Avian point count data were analyzed for bird activity minutes by species. We also calculated the percentage of observations for which interactions were observed. Migration data were analyzed for species abundance and diversity, abundance in relation to survey time (hawks per hour), flight direction, and migrant status.

Results

During February 2014 to January 2016, we conducted 96 large bird point counts, 192 small bird point counts (Appendix C), and 19 fall migration surveys (Appendix D) and recorded a total of 307.9 survey hours (Table 1). During avian point count surveys we recorded 8,791 and 5,227 respective minutes of activity for the 800 m (large bird) and 100 m (small bird) surveys, for a total of 14,018 minutes of bird activity across both years (Table 2). During migration surveys, we recorded a total of 510 individual birds (Table 3). Combined, both survey types documented 44 bird species occurring in Site 300 (Table 4).

Table 1. Total survey hours for combined avian surveys at Site 300 from February 2014-January 2016 (presented as year 1 and 2).

	Hours Surveyed		
Avian Point Counts	Year 1	Year 2	Total Hours
	February 2014 to January 2015	February 2015 to January 2016	
Large bird	72.0	72.0	144.0
Small bird	48.0	48.0	96.0
	September to November 2014	September to November 2015	
Migration Survey	36.0	31.9	67.9
Total	156.0	151.9	307.9

Table 2. Total minutes of bird activity for avian point count surveys at Site 300 from February 2014-January 2016 (presented as year 1 and 2).

	Minutes of Bird Activity		
Avian Point Counts	Year 1	Year 2	Total
Large bird	4,090	4,701	8,791
Small bird	2,911	2,316	5,227
Total	7,001	7,017	14,018

Table 3. Total individual observations for 2014 and 2015 fall migration surveys at Site 300.

	Number of Individuals		
	September to November 2014	September to November 2015	Total
Migration Survey	305	205	510

Avian Point Counts

The total number of observations between survey years was similar for both large and small bird point counts. During the period from February 2014 through January 2015 (Year 1), we tallied 4,090 minutes of large bird activity. From February 2015 through January 2016 (Year 2), we tallied 4,701 minutes of large bird activity. Small bird surveys recorded 2,911 minutes of activity during Year 1 and 2,316 minutes of activity during Year 2. Avian point count observations over the two-year survey period totaled 14,018 minutes of bird activity across all survey areas (Table 2).

Large Birds

We observed 12 species during the large bird point counts (Table 4). The most common species observed based on minutes of activity observed in the survey area across both years were common raven ($n=5,610$), red-tailed hawk ($n=2,432$), turkey vulture ($n=285$), northern harrier ($n=160$), rough-legged hawk ($n=134$), golden eagle ($n=132$) and prairie falcon ($n=23$). We recorded few minutes of activity ($n \leq 6$) and observations of Cooper's hawk ($n=6$), ferruginous hawk ($n=3$), sharp-shinned hawk ($n=1$), Swainson's hawk ($n=1$), and western gull ($n=1$). We also recorded unidentified individuals of the genus *Buteo* ($n=2$), and *Accipiter* ($n=1$).

Table 4. Bird species observed at Site 300 during avian point count and migration surveys from February 2014 through January 2016, by survey type and order of incidence.

Species	Scientific Name	Point Counts		Migration
		Minutes of Bird Activity	Relative Incidence	Individuals
Large Birds (> crow sized)				
Common raven	<i>Corvus corax</i>	5,610	63.8%	n/a
Red-tailed hawk	<i>Buteo jamaicensis</i>	2,432	27.7%	134
Turkey vulture	<i>Cathartes aura</i>	285	3.2%	123
Northern harrier	<i>Circus cyaneus</i>	160	1.8%	41
Rough-legged hawk	<i>Buteo lagopus</i>	134	1.5%	2
Golden eagle	<i>Aquila chrysaetos</i>	132	1.5%	81
Prairie falcon	<i>Falco mexicanus</i>	23	0.3%	8
Cooper's hawk	<i>Accipiter cooperii</i>	6	0.1%	3
Ferruginous hawk	<i>Buteo regalis</i>	3	0.0%	3
Unidentified buteo	<i>Buteo sp.</i>	2	0.0%	2
Sharp-shinned hawk	<i>Accipiter striatus</i>	1	0.0%	2
Swainson's hawk	<i>Buteo swainsoni</i>	1	0.0%	n/a
Unidentified accipiter	<i>Accipiter sp.</i>	1	0.0%	n/a
Western gull	<i>Larus occidentalis</i>	1	0.0%	n/a
American white pelican	<i>Pelecanus erythrorhynchos</i>	n/a	n/a	16
Geese	<i>Anserinae</i>	n/a	n/a	60
Osprey	<i>Pandion haliaetus</i>	n/a	n/a	3
Peregrine falcon	<i>Falco peregrinus</i>	n/a	n/a	1
Red-shouldered hawk	<i>Buteo lineatus</i>	n/a	n/a	2
Unidentified raptor	<i>Falconiformes</i>	n/a	n/a	2
Small Birds (< crow sized)				
White-crowned sparrow	<i>Zonotrichia leucophrys</i>	1,532	29.3%	n/a
Mixed sparrows	<i>Emberizidae</i>	1,196	22.9%	n/a
Savannah sparrow	<i>Passerculus sandwichensis</i>	633	12.1%	n/a
Brewer's blackbird	<i>Euphagus cyanocephalus</i>	405	7.7%	n/a
Western meadowlark	<i>Sturnella neglecta</i>	294	5.6%	n/a
Rock wren	<i>Salpinctes obsoletus</i>	270	5.2%	n/a
Unidentified sparrow	<i>Emberizidae</i>	258	4.9%	n/a
Horned lark	<i>Eremophila alpestris</i>	158	3.0%	n/a
Say's phoebe	<i>Sayornis saya</i>	149	2.9%	27
American kestrel	<i>Falco sparverius</i>	39	0.7%	n/a
Loggerhead shrike	<i>Lanius ludovicianus</i>	38	0.7%	n/a
Tricolored blackbird	<i>Agelaius tricolor</i>	37	0.7%	n/a

Species	Scientific Name	Point Counts		Migration
		Minutes of Bird Activity	Relative Incidence	Individuals
House finch	<i>Haemorhous mexicanus</i>	36	0.7%	n/a
Rock pigeon	<i>Columba livia</i>	27	0.5%	n/a
White-throated swift	<i>Aeronautes saxatalis</i>	26	0.5%	n/a
Barn swallow	<i>Hirundo rustica</i>	19	0.4%	n/a
Rufous-crowned sparrow	<i>Aimophila ruficeps</i>	13	0.2%	n/a
Northern rough-winged swallow	<i>Stelgidopteryx serripennis</i>	12	0.2%	n/a
Unidentified blackbird	<i>Agelaius sp.</i>	12	0.2%	n/a
Mallard	<i>Anas platyrhynchos</i>	12	0.2%	n/a
Burrowing owl	<i>Athene cunicularia</i>	8	0.2%	n/a
Unidentified lark	<i>Alaudidae</i>	8	0.2%	n/a
Anna's hummingbird	<i>Calypte anna</i>	7	0.1%	n/a
Cliff swallow	<i>Petrochelidon pyrrhonota</i>	7	0.1%	n/a
Mourning dove	<i>Zenaida macroura</i>	6	0.1%	n/a
European starling	<i>Sturnus vulgaris</i>	6	0.1%	n/a
Northern flicker	<i>Colaptes auratus cafer</i>	3	0.1%	n/a
Western kingbird	<i>Tyrannus verticalis</i>	3	0.1%	n/a
Red-winged blackbird	<i>Agelaius phoeniceus</i>	3	0.1%	n/a
Golden-crowned sparrow	<i>Zonotrichia atricapilla</i>	2	0.0%	n/a
Unidentified hummingbird	<i>Trochilidae</i>	2	0.0%	n/a
Lesser goldfinch	<i>Spinus psaltria</i>	2	0.0%	n/a
Unidentified swallow	<i>Hirundinidae</i>	2	0.0%	n/a
Black phoebe	<i>Sayornis nigricans</i>	1	0.0%	n/a
Unidentified finch	<i>Fringilidae</i>	1	0.0%	n/a

*n/a = no data collected for this species

The number of bird activity minutes was almost always higher than the number of individuals, because individual birds were generally tracked for more than one minute within the survey area. Though lower in number, the count of individuals generally mirrored that of observation minutes. The exception to this was the rough-legged hawk, for which one or two individuals were observed perch hunting within the EOP survey area for many minutes on two separate survey dates during 2014. With the exception of the highly social and ubiquitous common raven, most species were observed as individuals moving through the survey area, or spending extended periods hunting the hillside. As described in the Methods section, the inherent bias of this survey protocol promotes multiple counts of bird activity of individual birds, regardless of whether they remain consistently within the survey area or leave and return multiple times.

During some surveys, individuals were observed perched within the survey area for the duration of the survey. Other individuals moved quickly through the survey area for a total of only one tallied minute of observation time.

Common ravens were observed as individuals, in pairs, or in flocks throughout the year and at all sites. We observed some seasonal trends in other species, most notably increases in breeding season observations for golden eagles and red-tailed hawks. In the case of red-tailed hawks, we observed 2 active nests within the 800 m radius survey area, at which incubation, brooding, and fledging activities were observed. A territorial golden eagle pair was routinely observed perched on a PG&E power distribution pole approximately 1,150 m southeast of the WOP, and thus 350 m outside of the survey area. While this pair could be seen hunting the hillsides throughout Site 300, and occasionally was recorded within the avian point count survey area, no sign of golden eagle nesting activity was observed within Site 300. Conversely, we observed rough-legged hawk and prairie falcon only during winter months, which were likely multiple observations of a single individual overwintering in the rangeland on the northeast side of Site 300. Ferruginous hawk was also only observed during winter surveys.

Seven species were seen in both years of the survey, accounting for 98.1% of the recorded bird activity minutes. Those species were common raven (63.8%), red-tailed hawk (27.7%), turkey vulture (3.2%), northern harrier (1.8%), golden eagle (1.5%), Cooper's hawk (0.1%), and ferruginous hawk (0.0%). Rough-legged hawk (1.5%) and Swainson's hawk (0.0%) were only observed during the first year of the survey. Prairie falcon (0.3%), sharp-shinned hawk (0.0%), and western gull (0.0%) were only observed during the second year of the survey (Table 4).

Interactions between individual birds were often observed during large bird point counts. Excluding common raven observations (which are almost always interacting with each other), 32% of observations across both years included some type of interaction between observed individuals. Interactions ranged from simply flying in the vicinity of another bird to aggressive chases and mobbing behavior.

Small Birds

We observed 28 bird species during the small bird point count surveys (Table 4). The most common species by minutes of bird activity across both years and accounting for 65.8% of recorded observations were white-crowned sparrow ($n=1,532$), savannah sparrow ($n=633$), Brewer's blackbird ($n=405$), western meadowlark ($n=116$), rock wren ($n=270$), horned lark ($n=158$), and Say's phoebe ($n=149$). Mixed sparrows ($n=1,196$) and unidentified sparrows ($n=258$) accounted for another 27.8% of observed minutes of bird activity. The remaining 6.4% of observed minutes of bird activity were accounted by the other 20 species ($n=307$) as well as 5 classifications of unidentified species ($n=25$).

We observed small birds moving quickly through the site as well as perching and foraging throughout the duration of the survey. There were also seasonal changes observed for different

species. Savannah sparrow, rock wren, and white-crowned sparrow, (as well as mixed sparrows and unidentified sparrows) were mostly absent during the breeding season. Horned lark observations peaked in April. Say's phoebe and western meadowlark were present sporadically throughout the year, with moderate increases of activity in the fall and winter for both species.

Most small bird species were observed consistently across both years; however, there was a slight decrease in species diversity between years. Five species observed in the first year were not observed in the second year of the study. These species were burrowing owl ($n=8$), lesser goldfinch ($n=2$), mallard ($n=12$), northern flicker ($n=3$), and tricolored blackbird ($n=37$).

Bird interactions were more common for small birds, mostly due to flocking behavior (in flight and foraging). Across both years, 43% of observations included some type of interaction between observed individuals.

Migration Surveys

Across both years, we observed consistent numbers of common raptor species present within Site 300, including red-tailed hawk ($n=134$), turkey vulture ($n=123$), golden eagle ($n=81$), northern harrier ($n=41$), and American kestrel ($n=27$). In addition to these species, we made occasional observations of individuals of other species including prairie falcon ($n=8$), Cooper's hawk ($n=3$), ferruginous hawk ($n=3$), osprey ($n=3$), red-shouldered hawk ($n=2$), rough-legged hawk ($n=2$), sharp-shinned hawk ($n=2$), and peregrine falcon ($n=1$). In 2014, we also observed a flock of unidentified geese ($n=60$), and a flock of American white pelican ($n=16$; Table 4, Figure 1).

For most migration observations, we were unable to conclusively assign a migrant status beyond "Dispersing/Unknown". This was in large part because the most common species observed during migration surveys are also present in central California throughout the year. Without the presence of a defined migration corridor, there is no way to determine whether locally common individuals (e.g. red-tailed hawk, golden eagle) counted in this survey were local residents, dispersing individuals passing through, or overwintering birds in the Site 300 area. The exception were the resident pairs of red-tailed hawk and golden eagle which exhibited territorial behavior throughout the year. A total of 20 red-tailed hawk observations and 23 golden eagles observations were deemed to be resident status. These numbers likely represent repeat observations of the resident pairs. Based on 2-years surveying golden eagles within Site 300 (concurrent with avian point counts), we know that only one pair of eagles occupies a territory that overlaps with Site 300. Thus the 23 observations identified as "Resident" over the course of the two-years of migration surveys were likely just this resident pair counted multiple times. The remaining 58 of the 81 golden eagle observations could not be assigned a migration status beyond "Dispersing/Unknown", but it is likely that a percentage of these were also attributable to the two known resident birds. Without individual markings, we cannot determine this conclusively.

Across both years 73.5% of observations were classified as "Dispersing/Unknown", with 17.1%

“Migrant”, 8.4% “Resident”, and 1.0% “Wintering” (Table 5). In some instances, the “Migrant” status was straightforward, as was the case for the one-time observations of a flock of 60 geese and 16 pelicans. Similarly, we were able to assign “Migrant” status to Cooper’s hawk ($n=3$), osprey ($n=3$), red-shouldered hawk ($n=2$), sharp-shinned hawk ($n=2$), and peregrine falcon ($n=1$). Only ferruginous hawk ($n=3$) and rough-legged hawk ($n=2$) were assigned “Wintering” status.

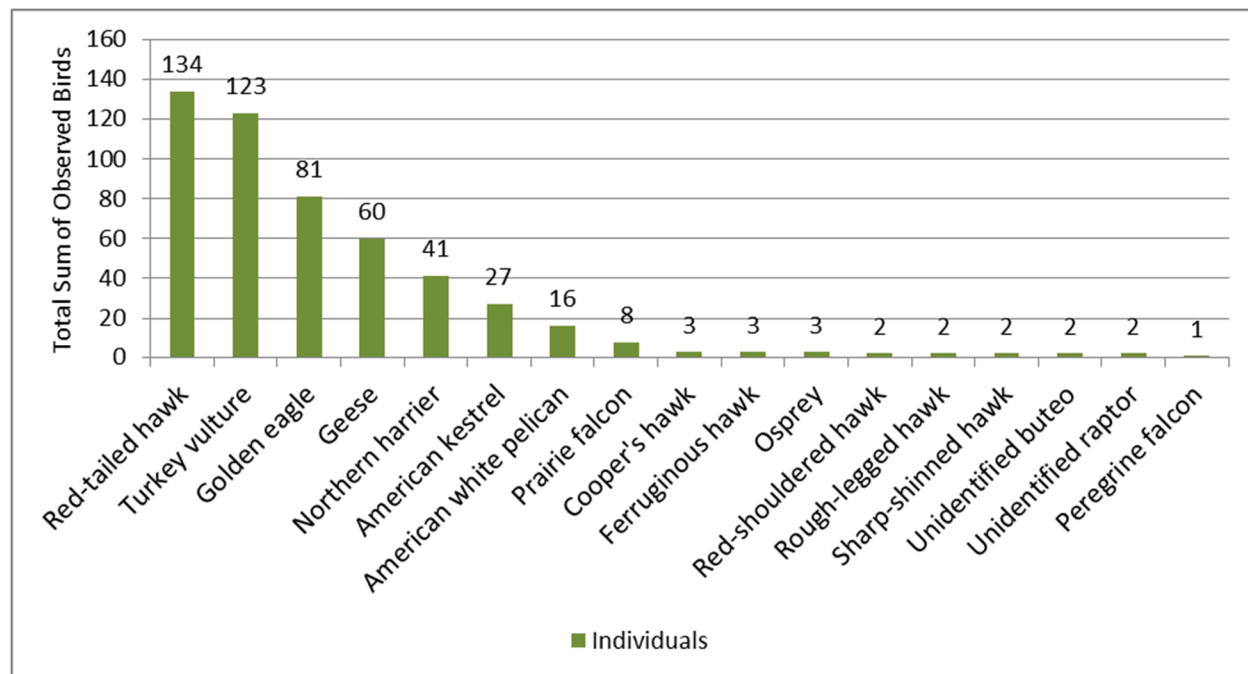


Figure 1. Totals for all birds observed during fall migration surveys at Site 300.

Table 5. Observations for 2014 and 2015 migration surveys at Site 300, including total count and migration status assessments by species.

Species	Dispersing/Unknown	Migrant	Resident	Wintering	Total
Red-tailed hawk	114		20		134
Turkey vulture	123				123
Golden eagle	58		23		81
Geese		60			60
Northern harrier	41				41
American kestrel	27				27
American white pelican		16			16
Prairie falcon	8				8
Cooper's hawk		3			3
Ferruginous hawk				3	3
Osprey		3			3
Red-shouldered hawk		2			2
Rough-legged hawk				2	2
Sharp-shinned hawk		2			2
Unidentified buteo	2				2
Unidentified raptor	2				2
Peregrine falcon		1			1
Total	375	87	43	5	510
Percentage	73.5%	17.1%	8.4%	1.0%	

Migration surveys did not identify a migration corridor at Site 300. While there appeared to be a moderate increase in observations during the month of October, there did not appear to be any consistent flight line or concentration point for migrants. Birds were observed as far as 3 km away, as close as directly overhead, everywhere in between, and moving in all directions. There were minor peaks of activity observed at Site 300; however, observations of bird activity and movement through Site 300 appear to conform to diffuse migration across the landscape. The average number of hawks observed per hour for 2014 and 2015 was 10.0 and 6.4 birds per hour, respectively. By comparison, the Golden Gate Raptor Observatory (GGRO), which annually monitors the fall raptor migration in the Marin Headlands, (85 km northwest of Site 300), saw an average of 57.3 and 74.5 birds per hour for the same survey dates in 2014 and 2015, respectively (Chris Briggs, personal communication). For all survey dates, the GGRO recorded higher rates of passage as well as greater species diversity (Table 6).

Table 6. 2014-2015 Migration survey rates of activity and number of species observed for Site

300 and the GGRO.

	Site 300		GGRO†	
Date	hawks/hour*	#species*	hawks/hour	#species
9/9/2014	10.3	7	33.6	11
9/30/2014	6.8	5	126.5	13
10/7/2014	4.5	5	46.4	11
10/15/2014	5.8	4	29.4	8
10/28/2014	7.8	5	42.7	11
11/4/2014	7.0	5	83.8	15
11/12/2014	10.0	8	39.0	12
9/21/2015	4.0	5	99.8	13
9/23/2015	5.0	4	182.2	15
9/28/2015	6.0	6	72.6	10
10/6/2015	17.0	9	100.8	12
10/14/2015	6.3	6	51.8	10
10/21/2015	3.8	4	6.7	10
11/9/2015	6.0	5	n/a**	n/a**
11/11/2015	3.3	4	33.0	9

†GGRO data used with permission by Chris Briggs of the GGRO (1/25/2016)

*excludes non raptor species observed during migration counts (pelicans and geese)

**No data collected at GGRO on 11/9/2015 due to thunderstorms

Across 2014 and 2015 there was no dominant trend for flight direction. Birds were observed flying in all directions (Figure 2 and 3). In October and November of 2015, there were minor increases in the occurrence of birds flying southwest, south, and southeast, but this was not reflected in the 2014 survey. These observations are consistent with a diffuse migration across the landscape, including movements of residents, local dispersers and overwintering birds.

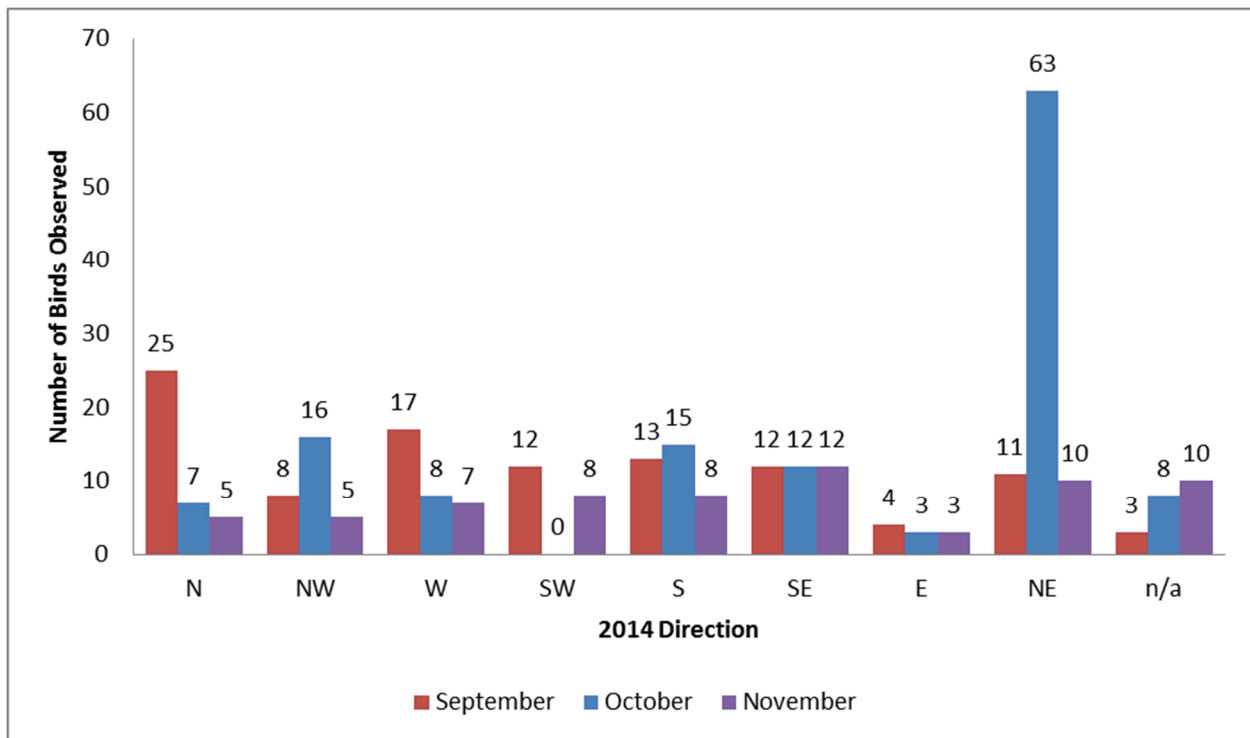


Figure 2. Observed flight directions by month for all birds during 2014 migration surveys (note: the spikes in values for N and NE are respectively accounted for almost entirely by a flock of 16 pelicans and 60 geese).

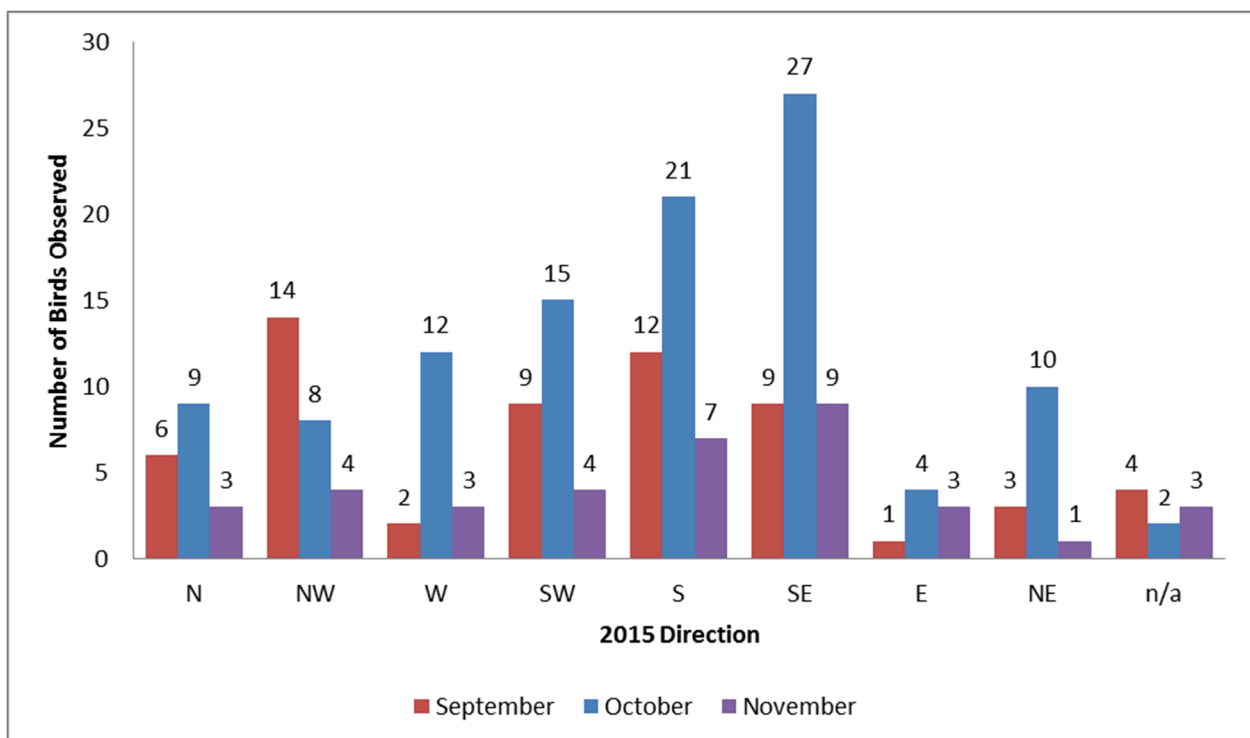


Figure 3. Observed flight directions by month for all birds during 2015 migration surveys.

Discussion

The goals of these surveys were to: 1) collect minutes of bird activity within Site 300, 2) consider relative abundance of the different bird species occurring within the Site, 3) collect behavioral information, and 4) provide compelling evidence to determine the status of the Site in terms of migration corridor or migration stopover site. In all instances we succeeded in meeting these goals. Our surveys detected the presence of 44 bird species exhibiting a variety of different behaviors within Site 300. Over the course of two years, we recorded observations of breeding, territoriality, foraging, dispersal movements, and migration across the landscape. Birds were observed individually, in pairs, or large flocks. Observed interactions were both non-aggressive and aggressive. Territorial birds were present and actively defending their nest area. Other birds were present only as winter residents. Some birds were observed repeatedly hunting a single hillside. In some cases, the observed birds were present within the survey area for the duration of the survey. At other times, they quickly passed through the site.

Site 300 occurs within the Pacific Flyway, an area extending from Alaska to the Patagonia Region of South America, including the western United States. Millions of migratory birds utilize the Pacific Flyway annually during their southbound and northbound migrations. Located within the Diablo Range of central California, Site 300 occurs within the winter and year round ranges of many other species. Given this information, it is not surprising to see some evidence of migration, as might be observed at many locations within this region. However, these data show that at the local level, a distinct migration corridor does not exist at Site 300. The topography surrounding Site 300 and prevailing winds do not provide the conditions that concentrate migratory birds, as happens along the coast, isolated mountain chains, or other similar topographic edges. Topography north and south may also act to funnel migratory birds away from Site 300.

Migration surveys at established raptor migration count sites tend to begin in mid-August and continue through the autumn months until weather or reduced numbers of migrants stop the counts. At the GGRO in the Marin Headlands, the count runs from mid-August through the first week of December. Migration counts are conducted daily, weather permitting. Only with this intensive effort is it possible to begin to draw solid conclusions regarding migrating birds and their populations. Surveys scheduled for a few days spread across the migration season may not be enough to detect all or any of the big flights that may occur during the season. The highest count of 17 hawk per hour on October 6, 2015 may represent the upper range Site 300 will ever see in a given year but this is far less than the numbers observed at a well-documented site like the GGRO where 182 hawk per hour were recorded during the same survey period. If future migration studies are conducted at Site 300, a more continuous effort is recommended to determine if peak flights that exceed what was observed in this study are occurring. In addition, surveys should consider the spring migration period during April and May.

References:

Briggs, Chris. 2016. Golden Gate Raptor Observatory (GGRO) unpublished data summarizing daily migration counts from Hawk Hill in the Marin Headlands coinciding with Site 300 migration survey dates during 2014 and 2015 (email communication on January 26, 2016).

Smallwood, K. S. and Lee Neher. 2008. *Map-based repowering of the Altamont Pass Wind Resource Area on burrowing owl burrows, raptor flights, and collision with wind turbines*. Final Project Report to the California Energy Commission, Public Interest Energy Research Program. Contract No. 500-01-032. Sacramento, California.

Smallwood, K. S. and C. Thelander. 2004. *Developing Methods to Reduce bird Mortality in the Altamont Pass Wind Resource Area*. Final Report to the California Energy Commission, Public Interest Energy Research – Environmental Area, Contract No. 500-01-019. Sacramento, California.

Appendix A. Flight Behaviors

Behavior	Description
Fly-through	Directed flight powered by active wing flaps
Flapping	Wing flaps to maintain lift at slow speeds
Gliding	Directional flight with no wing beats
Surfing	Wind-powered flights usually perpendicular to the wind direction
Soaring	Gradual turning with few wing beats, often powered by thermals
Column soaring	Gradual turning with few wing beats, using thermals or deflection updrafts to gain altitude
Circling	Tight circles with some wing beats, usually looking at something on ground
Contouring	Flights close to terrain, changing direction and height with terrain
Kiting	Stationary position maintained using wind currents. Wings are partially closed with little movement. Tail closed
Hovering	Stationary position maintained using frequent wing beats. Tail widely fanned
Fly-catching	Short flights to and from perch in pursuit of prey items
Diving	Wings recessed or folded for rapid downward flight, usually to attack prey or competitor
Attacking	Attacking a potential prey item or competitor, not involving a dive.
Chasing/Mobbing	Harassing a larger bird
Fleeing attacker	Evading predatory or competitive attack
Mobbed/Chased	Evading harassment by smaller birds
Flushed	Chased off perch
Ground-hopping	Hops along the ground while foraging
Carry prey	Self-explanatory
Carry nest material	Self-explanatory
Eating	Eating
Copulating	Self-explanatory
Displaying	Undulations, feet dangling, calling
Flocking	More than one bird flying together

Appendix B. Perch Structures

Building Communication tower Fence Ground Guy wire Meteorological tower Distribution pole top, Pole cross arm, Pole equipment, (e.g., jumpers, transformer, capacitor box)	Rock outcrop Sign Transformer box Transmission line Tree Water Other
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Appendix C. 2014-2016 LLNL Site 300 Avian Point Count History

Date	Survey Session	Survey Type	Survey Radius	Start Time	End Time
2/25/2014	LRD_Feb25	Large Bird	800m	9:10	10:40
2/25/2014	LRDa_Feb25	Small Bird	100m	10:52	11:52
2/25/2014	LRDb_Feb25	Small Bird	100m	11:31	12:01
2/25/2014	EOP_Feb25	Large Bird	800m	12:17	13:47
2/25/2014	WOP_Feb25	Large Bird	800m	14:00	15:30
2/25/2014	WOPa_Feb25	Small Bird	100m	15:36	16:06
2/25/2014	WOPb_Feb25	Small Bird	100m	16:12	16:42
2/26/2014	849_Feb26	Large Bird	800m	8:10	9:40
2/26/2014	849a_Feb26	Small Bird	100m	9:45	10:15
2/26/2014	849b_Feb26	Small Bird	100m	10:20	10:50
2/26/2014	EOPa_Feb26	Small Bird	100m	11:01	11:31
2/26/2014	EOPb_Feb26	Small Bird	100m	11:33	12:03
3/27/2014	WOP_Mar27	Large Bird	800m	7:54	9:24
3/27/2014	WOPa_Mar27	Small Bird	100m	7:56	8:26
3/27/2014	WOPb_Mar27	Small Bird	100m	8:45	9:15
3/27/2014	EOP_Mar27	Large Bird	800m	9:38	11:08
3/27/2014	EOPa_Mar27	Small Bird	100m	9:50	10:20
3/27/2014	EOPb_Mar27	Small Bird	100m	10:25	10:55
3/27/2014	LRD_Mar27	Large Bird	800m	11:30	13:00
3/27/2014	LRDa_Mar27	Small Bird	100m	11:27	11:57
3/27/2014	LRDb_Mar27	Small Bird	100m	12:00	12:30
3/27/2014	849_Mar27	Large Bird	800m	13:38	15:08
3/27/2014	849a_Mar27	Small Bird	100m	14:00	14:30
3/27/2014	849b_Mar27	Small Bird	100m	13:17	13:47
4/21/2014	EOP_Apr21	Large Bird	800m	8:03	9:33
4/21/2014	EOPa_Apr21	Small Bird	100m	7:52	8:22
4/21/2014	EOPb_Apr21	Small Bird	100m	8:27	8:57
4/21/2014	WOP_Apr21	Large Bird	800m	9:50	11:20
4/21/2014	WOPa_Apr21	Small Bird	100m	9:19	9:49
4/21/2014	WOPb_Apr21	Small Bird	100m	10:03	10:33
4/21/2014	849_Apr21	Large Bird	800m	12:20	13:50
4/21/2014	849b_Apr21	Small Bird	100m	10:55	11:25
4/21/2014	849a_Apr21	Small Bird	100m	12:15	12:45
4/21/2014	LRD_Apr21	Large Bird	800m	14:20	15:50
4/21/2014	LRDa_Apr21	Small Bird	100m	14:13	14:43
4/21/2014	LRDb_Apr21	Small Bird	100m	14:46	15:16
5/22/2014	849_May22	Large Bird	800m	8:22	9:52
5/22/2014	849b_May22	Small Bird	100m	7:44	8:14
5/22/2014	849a_May22	Small Bird	100m	8:24	8:54
5/22/2014	LRD_May22	Large Bird	800m	10:10	11:40
5/22/2014	LRDb_May22	Small Bird	100m	10:10	10:40
5/22/2014	LRDa_May22	Small Bird	100m	10:48	11:18

Date	Survey Session	Survey Type	Survey Radius	Start Time	End Time
5/22/2014	EOP_May22	Large Bird	800m	11:55	13:25
5/22/2014	EOPa_May22	Small Bird	100m	11:57	12:27
5/22/2014	EOPb_May22	Small Bird	100m	12:30	13:00
5/22/2014	WOP_May22	Large Bird	800m	13:45	15:15
5/22/2014	WOPa_May22	Small Bird	100m	13:40	14:10
5/22/2014	WOPb_May22	Small Bird	100m	14:18	14:48
6/26/2014	LRD_Jun26	Large Bird	800m	8:00	9:30
6/26/2014	LRDb_Jun26	Small Bird	100m	7:55	8:25
6/26/2014	LRDa_Jun26	Small Bird	100m	8:33	9:03
6/26/2014	EOP_Jun26	Large Bird	800m	9:50	11:20
6/26/2014	EOPa_Jun26	Small Bird	100m	9:50	10:20
6/26/2014	EOPb_Jun26	Small Bird	100m	10:25	10:55
6/26/2014	WOP_Jun26	Large Bird	800m	11:36	13:06
6/26/2014	WOPa_Jun26	Small Bird	100m	11:37	12:07
6/26/2014	WOPb_Jun26	Small Bird	100m	12:20	12:50
6/26/2014	849_Jun26	Large Bird	800m	13:25	14:55
6/26/2014	849a_Jun26	Small Bird	100m	13:25	13:55
6/26/2014	849b_Jun26	Small Bird	100m	13:58	14:28
7/17/2014	EOP_Jul17	Large Bird	800m	7:30	9:00
7/17/2014	EOPa_Jul17	Small Bird	100m	7:30	8:00
7/17/2014	EOPb_Jul17	Small Bird	100m	8:05	8:35
7/17/2014	WOP_Jul17	Large Bird	800m	9:15	10:45
7/17/2014	WOPa_Jul17	Small Bird	100m	9:15	9:45
7/17/2014	WOPb_Jul17	Small Bird	100m	9:50	10:20
7/17/2014	849_Jul17	Large Bird	800m	11:00	12:30
7/17/2014	849a_Jul17	Small Bird	100m	11:02	11:32
7/17/2014	849b_Jul17	Small Bird	100m	11:37	12:07
7/17/2014	LRD_Jul17	Large Bird	800m	12:50	14:20
7/17/2014	LRDa_Jul17	Small Bird	100m	12:48	13:18
7/17/2014	LRDb_Jul17	Small Bird	100m	13:20	13:50
8/19/2014	WOP_Aug19	Large Bird	800m	8:00	9:30
8/19/2014	WOPa_Aug19	Small Bird	100m	7:55	8:25
8/19/2014	WOPb_Aug19	Small Bird	100m	8:35	9:05
8/19/2014	849_Aug19	Large Bird	800m	9:45	11:15
8/19/2014	849a_Aug19	Small Bird	100m	9:48	10:18
8/19/2014	849b_Aug19	Small Bird	100m	10:30	11:00
8/19/2014	LRD_Aug19	Large Bird	800m	11:35	13:05
8/19/2014	LRDa_Aug19	Small Bird	100m	11:35	12:05
8/19/2014	LRDb_Aug19	Small Bird	100m	12:08	12:38
8/19/2014	EOP_Aug19	Large Bird	800m	13:20	14:50
8/19/2014	EOPa_Aug19	Small Bird	100m	13:20	13:50
8/19/2014	EOPb_Aug19	Small Bird	100m	13:52	14:22
9/22/2014	LRD_Sep22	Large Bird	800m	8:03	9:33
9/22/2014	LRDa_Sep22	Small Bird	100m	8:00	8:30

Date	Survey Session	Survey Type	Survey Radius	Start Time	End Time
9/22/2014	LRDb_Sep22	Small Bird	100m	8:40	9:10
9/22/2014	EOP_Sep22	Large Bird	800m	9:50	11:20
9/22/2014	EOPa_Sep22	Small Bird	100m	9:50	10:20
9/22/2014	EOPb_Sep22	Small Bird	100m	10:25	10:55
9/22/2014	WOP_Sep22	Large Bird	800m	11:30	13:00
9/22/2014	WOPa_Sep22	Small Bird	100m	11:35	12:05
9/22/2014	WOPb_Sep22	Small Bird	100m	12:10	12:40
9/22/2014	849_Sep22	Large Bird	800m	13:15	14:45
9/22/2014	849a_Sep22	Small Bird	100m	13:17	13:47
9/22/2014	849b_Sep22	Small Bird	100m	13:50	14:20
10/14/2014	849_Oct14	Large Bird	800m	7:40	9:10
10/14/2014	849a_Oct14	Small Bird	100m	7:45	8:15
10/14/2014	849b_Oct14	Small Bird	100m	8:20	8:50
10/14/2014	LRD_Oct14	Large Bird	800m	9:37	11:07
10/14/2014	LRDa_Oct14	Small Bird	100m	9:35	10:05
10/14/2014	LRDb_Oct14	Small Bird	100m	10:08	10:38
10/14/2014	EOP_Oct14	Large Bird	800m	11:24	12:54
10/14/2014	EOPa_Oct14	Small Bird	100m	11:23	11:53
10/14/2014	EOPb_Oct14	Small Bird	100m	11:55	12:25
10/14/2014	WOP_Oct14	Large Bird	800m	13:06	14:36
10/14/2014	WOPa_Oct14	Small Bird	100m	13:07	13:37
10/14/2014	WOPb_Oct14	Small Bird	100m	13:43	14:13
11/18/2014	EOP_Nov18	Large Bird	800m	7:55	9:25
11/18/2014	EOPa_Nov18	Small Bird	100m	7:55	8:25
11/18/2014	EOPb_Nov18	Small Bird	100m	8:28	8:58
11/18/2014	WOP_Nov18	Large Bird	800m	9:40	11:10
11/18/2014	WOPa_Nov18	Small Bird	100m	9:39	10:09
11/18/2014	WOPb_Nov18	Small Bird	100m	10:14	10:44
11/18/2014	849_Nov18	Large Bird	800m	11:25	12:55
11/18/2014	849a_Nov18	Small Bird	100m	11:25	11:55
11/18/2014	849b_Nov18	Small Bird	100m	11:58	12:28
11/18/2014	LRD_Nov18	Large Bird	800m	13:20	14:50
11/18/2014	LRDa_Nov18	Small Bird	100m	13:15	13:45
11/18/2014	LRDb_Nov18	Small Bird	100m	13:47	14:17
12/10/2014	WOP_Dec10	Large Bird	800m	7:55	9:25
12/10/2014	WOPa_Dec10	Small Bird	100m	7:55	8:25
12/10/2014	WOPb_Dec10	Small Bird	100m	8:30	9:00
12/10/2014	849_Dec10	Large Bird	800m	9:40	11:10
12/10/2014	849a_Dec10	Small Bird	100m	9:44	10:14
12/10/2014	849b_Dec10	Small Bird	100m	10:16	10:46
12/10/2014	EOP_Dec10	Large Bird	800m	11:35	13:05
12/10/2014	EOPa_Dec10	Small Bird	100m	11:34	12:04
12/10/2014	EOPb_Dec10	Small Bird	100m	12:06	12:36
12/10/2014	LRD_Dec10	Large Bird	800m	13:40	15:10

Date	Survey Session	Survey Type	Survey Radius	Start Time	End Time
12/10/2014	LRDa_Dec10	Small Bird	100m	13:40	14:10
12/10/2014	LRDb_Dec10	Small Bird	100m	14:15	14:45
1/8/2015	LRD_Jan8	Large Bird	800m	8:27	9:57
1/8/2015	LRDa_Jan8	Small Bird	100m	8:25	8:55
1/8/2015	LRDb_Jan8	Small Bird	100m	8:57	9:27
1/8/2015	EOP_Jan8	Large Bird	800m	10:12	11:42
1/8/2015	EOPa_Jan8	Small Bird	100m	10:12	10:42
1/8/2015	EOPb_Jan8	Small Bird	100m	10:44	11:14
1/8/2015	WOP_Jan8	Large Bird	800m	11:50	13:20
1/8/2015	WOPa_Jan8	Small Bird	100m	11:54	12:24
1/8/2015	WOPb_Jan8	Small Bird	100m	12:27	12:57
1/8/2015	849_Jan8	Large Bird	800m	13:35	15:05
1/8/2015	849a_Jan8	Small Bird	100m	13:35	14:05
1/8/2015	849b_Jan8	Small Bird	100m	14:08	14:38
2/11/2015	849_Feb11	Large Bird	800m	8:05	9:35
2/11/2015	849a_Feb11	Small Bird	100m	8:08	8:38
2/11/2015	849b_Feb11	Small Bird	100m	8:40	9:10
2/11/2015	LRD_Feb11	Large Bird	800m	10:17	11:47
2/11/2015	LRDa_Feb11	Small Bird	100m	10:14	10:44
2/11/2015	LRDb_Feb11	Small Bird	100m	10:46	11:16
2/11/2015	EOP_Feb11	Large Bird	800m	12:00	13:30
2/11/2015	EOPa_Feb11	Small Bird	100m	12:00	12:30
2/11/2015	EOPb_feb11	Small Bird	100m	12:32	13:02
2/11/2015	WOP_feb11	Large Bird	800m	13:45	15:15
2/11/2015	WOPa_feb11	Small Bird	100m	13:45	14:15
2/11/2015	WOPb_feb11	Small Bird	100m	14:18	14:48
3/26/2015	LRD_Mar26	Large Bird	800m	8:30	10:00
3/26/2015	LRDa_Mar26	Small Bird	100m	8:30	9:00
3/26/2015	LRDb_Mar26	Small Bird	100m	9:03	9:33
3/26/2015	EOP_Mar26	Large Bird	800m	10:20	11:50
3/26/2015	EOPa_Mar26	Small Bird	100m	10:20	10:50
3/26/2015	EOPb_Mar26	Small Bird	100m	10:53	11:23
3/26/2015	WOP_Mar26	Large Bird	800m	12:05	13:35
3/26/2015	WOPa_Mar26	Small Bird	100m	12:08	12:38
3/26/2015	WOPb_Mar26	Small Bird	100m	12:40	13:10
3/26/2015	849_Mar26	Large Bird	800m	13:55	15:25
3/26/2015	849a_Mar26	Small Bird	100m	13:55	14:25
3/26/2015	849b_Mar26	Small Bird	100m	14:27	14:57
4/14/2015	WOP_Apr14	Large Bird	800m	8:15	9:45
4/14/2015	WOPa_Apr14	Small Bird	100m	8:15	8:45
4/14/2015	WOPb_Apr14	Small Bird	100m	8:48	9:18
4/14/2015	849_Apr14	Large Bird	800m	10:00	11:30
4/14/2015	849a_Apr14	Small Bird	100m	10:05	10:35
4/14/2015	849b_Apr14	Small Bird	100m	10:38	11:08

Date	Survey Session	Survey Type	Survey Radius	Start Time	End Time
4/14/2015	LRD_Apr14	Large Bird	800m	11:50	13:20
4/14/2015	LRDa_Apr14	Small Bird	100m	11:48	12:18
4/14/2015	LRDb_Apr14	Small Bird	100m	12:20	12:50
4/14/2015	EOP_Apr14	Large Bird	800m	13:40	15:10
4/14/2015	EOPa_Apr14	Small Bird	100m	13:38	14:08
4/14/2015	EOPb_Apr14	Small Bird	100m	14:10	14:40
5/20/2015	849_May20	Large Bird	800m	7:45	9:15
5/20/2015	849a_May20	Small Bird	100m	7:45	8:15
5/20/2015	849b_May20	Small Bird	100m	8:20	8:50
5/20/2015	LRD_May20	Large Bird	800m	9:40	11:10
5/20/2015	LRDa_May20	Small Bird	100m	9:38	10:08
5/20/2015	LRDb_May20	Small Bird	100m	10:11	10:41
5/20/2015	EOP_May20	Large Bird	800m	11:26	12:56
5/20/2015	EOPa_May20	Small Bird	100m	11:25	11:55
5/20/2015	EOPb_May20	Small Bird	100m	11:57	12:27
5/20/2015	WOP_May20	Large Bird	800m	13:11	14:41
5/20/2015	WOPa_May20	Small Bird	100m	13:11	13:41
5/20/2015	WOPb_May20	Small Bird	100m	13:45	14:15
6/16/2015	LRD_Jun16	Large Bird	800m	8:30	10:00
6/16/2015	LRDa_Jun16	Small Bird	100m	8:30	9:00
6/16/2015	LRDb_Jun16	Small Bird	100m	9:03	9:33
6/16/2015	EOP_Jun16	Large Bird	800m	10:15	11:45
6/16/2015	EOPa_Jun16	Small Bird	100m	10:13	10:43
6/16/2015	EOPb_Jun16	Small Bird	100m	10:45	11:15
6/16/2015	WOP_Jun16	Large Bird	800m	12:00	13:30
6/16/2015	WOPa_Jun16	Small Bird	100m	12:00	12:30
6/16/2015	WOPb_Jun16	Small Bird	100m	12:32	13:02
6/16/2015	849_Jun16	Large Bird	800m	13:45	15:15
6/16/2015	849a_Jun16	Small Bird	100m	13:45	14:15
6/16/2015	849b_Jun16	Small Bird	100m	14:17	14:47
7/15/2015	849a_Jul15	Small Bird	100m	8:30	9:00
7/15/2015	849b_Jul15	Small Bird	100m	9:03	9:33
7/15/2015	LRDa_Jul15	Small Bird	100m	9:40	10:10
7/15/2015	LRDb_Jul15	Small Bird	100m	10:12	10:42
7/15/2015	EOPa_Jul15	Small Bird	100m	10:52	11:22
7/15/2015	EOPb_Jul15	Small Bird	100m	11:24	11:54
7/15/2015	WOPa_Jul15	Small Bird	100m	12:00	12:30
7/15/2015	WOPb_Jul15	Small Bird	100m	12:34	13:04
7/29/2015	LRD_Jul29	Large Bird	800m	8:40	10:10
7/29/2015	WOP_Jul29	Large Bird	800m	10:45	12:15
7/29/2015	EOP_Jul29	Large Bird	800m	12:30	14:00
7/29/2015	849_Jul29	Large Bird	800m	14:15	15:45
8/10/2015	WOPa_Aug10	Small Bird	100m	9:30	10:00
8/10/2015	WOPb_Aug10	Small Bird	100m	10:02	10:32

Date	Survey Session	Survey Type	Survey Radius	Start Time	End Time
8/10/2015	EOPa_Aug10	Small Bird	100m	10:42	11:12
8/10/2015	EOPb_Aug10	Small Bird	100m	11:15	11:45
8/10/2015	LRDa_Aug10	Small Bird	100m	14:35	15:05
8/10/2015	LRDb_Aug10	Small Bird	100m	15:08	15:38
8/13/2015	849_Aug13	Large Bird	100m	8:20	9:50
8/13/2015	849a_Aug13	Small Bird	100m	9:57	10:27
8/13/2015	849b_Aug13	Small Bird	800m	10:35	11:05
8/13/2015	LRD_Aug13	Large Bird	800m	11:20	12:50
8/13/2015	EOP_Aug13	Large Bird	800m	13:05	14:35
8/13/2015	WOP_Aug13	Large Bird	800m	14:45	16:15
9/21/2015	EOPb_Sep21	Small Bird	100m	8:17	8:47
9/21/2015	EOPa_Sep21	Small Bird	100m	8:50	9:20
9/21/2015	849b_Sep21	Small Bird	100m	9:30	10:00
9/21/2015	849a_Sep21	Small Bird	100m	13:36	14:06
9/22/2015	LRDb_Sep22	Small Bird	100m	11:25	11:55
9/22/2015	LRDa_Sep22	Small Bird	100m	11:57	12:27
9/22/2015	LRD_Sep22	Large Bird	800m	12:30	14:00
9/22/2015	WOPb_Sep22	Small Bird	100m	14:12	14:42
9/22/2015	WOPa_Sep22	Small Bird	100m	14:44	15:14
9/22/2015	WOP_Sep22	Large Bird	800m	15:15	16:45
9/23/2015	EOP_Sep23	Large Bird	800m	8:00	9:30
9/23/2015	849_Sep23	Large Bird	800m	9:55	11:25
10/13/2015	LRDb_Oct13	Small Bird	100m	10:00	10:30
10/13/2015	LRDa_Oct13	Small Bird	100m	10:40	11:10
10/13/2015	EOP_Oct13	Large Bird	800m	11:25	12:55
10/13/2015	EOPa_Oct13	Small Bird	100m	11:40	12:10
10/13/2015	EOPb_Oct13	Small Bird	100m	12:15	12:45
10/13/2015	WOPb_Oct13	Small Bird	100m	12:55	13:25
10/13/2015	WOP_Oct13	Large Bird	800m	13:08	14:38
10/13/2015	WOPa_Oct13	Small Bird	100m	13:35	14:05
10/13/2015	849b_Oct13	Small Bird	100m	14:20	14:50
10/14/2015	849a_Oct14	Small Bird	100m	7:55	8:25
10/14/2015	849_Oct14	Large Bird	800m	8:30	10:00
10/21/2015	LRD_Oct21	Large Bird	800	8:25	9:55
11/18/2015	EOP_Nov18	Large Bird	800m	8:30	10:00
11/18/2015	EOPa_Nov18	Small Bird	100m	8:35	9:05
11/18/2015	EOPb_Nov18	Small Bird	100m	9:10	9:40
11/18/2015	LRD_Nov18	Large Bird	800m	10:15	11:45
11/18/2015	LRDb_Nov18	Small Bird	100m	10:15	10:45
11/18/2015	LRDa_Nov18	Small Bird	100m	10:55	11:25
11/18/2015	WOP_Nov18	Large Bird	800m	12:00	13:30
11/18/2015	WOPa_Nov18	Small Bird	100m	12:05	12:35
11/18/2015	WOPb_Nov18	Small Bird	100m	12:43	13:13
11/18/2015	849_Nov18	Large Bird	800m	13:45	15:15

Date	Survey Session	Survey Type	Survey Radius	Start Time	End Time
11/18/2015	849a_Nov18	Small Bird	100m	13:50	14:20
11/18/2015	849b_Nov18	Small Bird	100m	14:30	15:00
12/15/2015	WOP_Dec15	Large Bird	800m	8:30	10:00
12/15/2015	WOPa_Dec15	Small Bird	100m	8:35	9:05
12/15/2015	WOPb_Dec15	Small Bird	100m	9:10	9:40
12/15/2015	849_Dec15	Large Bird	800m	10:12	11:42
12/15/2015	849a_Dec15	Small Bird	100m	10:20	10:50
12/15/2015	849b_Dec15	Small Bird	100m	11:00	11:30
12/15/2015	LRD_Dec15	Large Bird	800m	11:57	13:27
12/15/2015	LRDb_Dec15	Small Bird	100m	11:53	12:23
12/15/2015	LRDa_Dec15	Small Bird	100m	12:30	13:00
12/15/2015	EOP_Dec15	Large Bird	800m	13:45	15:15
12/15/2015	EOPb_Dec15	Small Bird	100m	13:40	14:10
12/15/2015	EOPa_Dec15	Small Bird	100m	14:15	14:45
1/7/2016	849_Jan7	Large Bird	800m	8:07	9:37
1/7/2016	849a_Jan7	Small Bird	100m	8:14	8:44
1/7/2016	849b_Jan7	Small Bird	100m	8:51	9:21
1/7/2016	LRD_Jan7	Large Bird	800m	10:00	11:30
1/7/2016	LRDa_Jan7	Small Bird	100m	9:59	10:29
1/7/2016	LRDb_Jan7	Small Bird	100m	10:35	11:05
1/7/2016	WOPb_Jan7	Small Bird	100m	11:55	12:25
1/7/2016	WOPa_Jan7	Small Bird	100m	12:30	13:00
1/7/2016	EOP_Jan7	Large Bird	800m	13:10	14:40
1/7/2016	EOPa_Jan7	Small Bird	100m	13:10	13:40
1/7/2016	EOPb_Jan7	Small Bird	100m	13:13	13:43
1/12/2016	WOP_Jan12	Large Bird	800m	9:40	11:10

Appendix D. 2014-2015 LLNL Site 300 Raptor Migration Survey History

Date	Location	Observer ¹	Start	End
September 2014				
9/9/2014	849	EPJ	9:15	12:15
9/9/2014	WOP	BMW	9:20	12:20
9/9/2014	EOP	EPJ	12:30	15:30
9/9/2014	LRD	BMW	12:45	15:45
9/30/2014	849	EPJ	9:50	13:50
October 2014				
10/7/2014	849	EPJ	9:40	13:40
10/15/2014	849	EPJ	9:30	13:30
10/28/2014	849	EPJ	9:50	13:50
November 2014				
11/4/2014	849	EPJ	9:35	13:35
11/12/2014	849	EPJ	10:00	14:00
September 2015				
9/21/2015	849	EPJ	9:30	13:30
9/23/2015	849	EPJ	10:00	14:00
9/28/2015	WOP	EPJ	9:30	13:40
October 2015				
10/6/2015	WOP	EPJ	10:00	14:00
10/14/2015	WOP	EPJ	10:15	14:30
10/21/2015	WOP	EPJ	10:15	14:15
November 2015				
11/9/2015 ²	WOP	EPJ	9:00	9:30
11/9/2015 ²	849	EPJ	11:45	14:45
11/11/2015	WOP	EPJ	9:30	13:30

¹Observer initials: EPJ=Eric Jepsen; BMW=Brittney Wendell

²This survey date divided due to lightning activity during the survey